RoboCon: Operator Interface for Robotic Applications

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ABSTRACT

Carnegie Mellon University (CMU) and Oak Ridge National Laboratories' (ORNL) Robotics and Process Systems Division (RPSD), are developing a state-of-the-art robot operator control station, dubbed *RoboCon*, with standardized hardware and software control interfaces to be adaptable to a variety of remote and robotic equipment currently funded by the DoE's Office of Science & Technology Robotics Technology Development Program (RTDP). The human operation and telerobotic and supervisory control of sophisticated and remote and robotic systems is a complex, tiring and non-intuitive activity. Since decontamination & decommissioning, selective equipment removal, mixed waste operations and in-tank cleanup are going to be a major future activity in Department of Energy's (DoE) environmental restoration and waste management (ER&WM) cleanup agenda, it seems necessary to utilize an operator control station and interface which maximizes operator comfort and productivity.

I. INTRODUCTION

The purpose of *RoboCon* is to provide a state-of-the-art control station for the evaluation and experimental phases of DoE's Robotics Technology Development Program (RTDP)- and Integrated Demonstration (ID)-program for a variety of focus areas, such as Decontamination and Dismantlement (D&D), Tanks and MIxed Waste. The control station provides the latest in display, control and software technologies for the upcoming testing and experimentation phase of the robotics development program underwritten by the DoE's OST. The console is designed to be flexible in terms of hardware and software configurations, to allow for

(i) testing of optimized display and control configurations,

(ii) reconfiguration of the control panels and consoles for varied robot systems, and

(iii) tailoring of the control station to suit different operators.

The need for such a control station is to be seen in the assertion that the control station and its interfaces play a big role in the teleoperation tasks of past, current and future robotic systems. The teleoperated robot system is but one part of the puzzle, since the human operator is responsible for controlling it. Hence

the efficiency of the operation and most probably also the capability of any system hinges on the adeptness of the operator controlling the machine. The impact of a properly configured control station and operator interface are thus crucial to the accuracy, dexterity and productivity of any operator controlling a remote worksystem. The best configurations for the display and control systems, and the software modules controlling the system displays, interfaces and outputs, need thus to be determined and evaluated through experimentation and real-world validation trials, just as much as the robot system has to be tested and its usefulness validated in such trials. The *RoboCon* system provides the robotics program with such an operator interface testing platform, with the latest in technology, allowing its utility and relevance to extend over the next one to two decades.

II. OBJECTIVES

The purpose of this system is to provide a flexible operator interface platform, applicable to many robotic applications, allowing for cost-effective testing and deployment of various robot systems for demonstration and field-use.The benefit is to be seen in the ability to control different robot systems through simple interchange of interface modules on the operator's chair, and the porting/development of interface display software to a common computing and programming platform. Cost savings can be realized through this system, since it represents a powerful and flexible test platform for evaluating the various robot systems currently available or under development for the OTD D&D program.

III. TECHNOLOGY DESCRIPTION

The proposed system (see Figure 1) consists of a large multi-screen projection-TV system framed on both sides by several high-resolution TV monitors, stereo speakers, a reconfigurable operator console and control chair module with various removable interface modules (such as joysticks, buttons, touch-screen, etc.), and a dual-arm kinematic master-

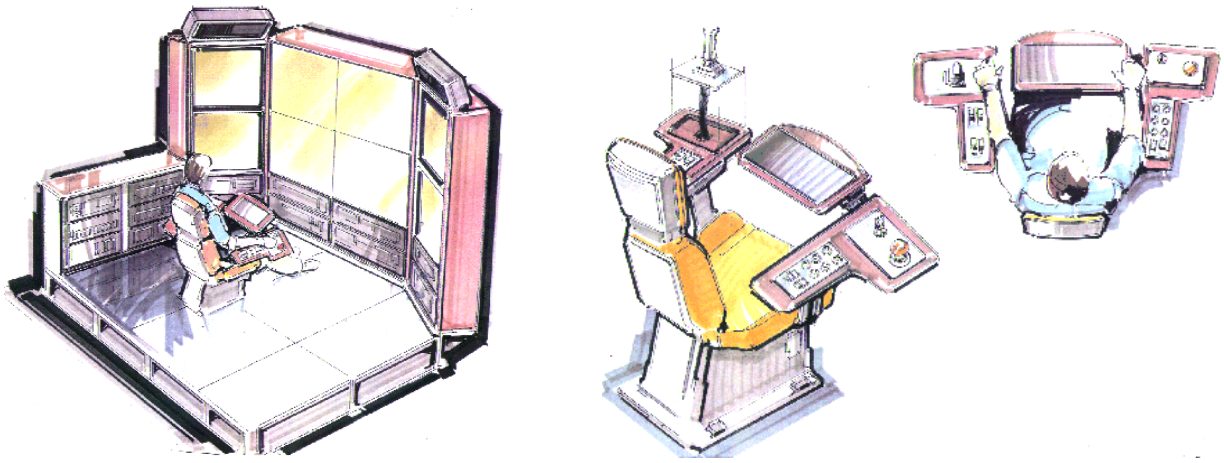

Figure 1*: RoboCom* Conceptual Layout with up-close view of operator control chair

arm set, all ergonomically mounted on a raised platform and integrated with the display and control electronics. The embedded computing consists of multiple VME racks to operate the consoles and to house the robot-control and interface computing (SPARC-based). The console computing consists of a real-time multi-processor Motorola CPU system operating with VxWorks and communicating with other hardware and interfaces via TCA/TCX and/or NDDS over ethernet, serial or parallel interface. Adequate rack space is also provided for the integration of video recorders and other computing platforms such as Silicon Graphics Workstations. All hardware systems support the C^{++}-based programming environment for the re-programmable operator interfaces and displays. Compatibility with other DoE console and controller efforts will be enforced at the hardware (VME, VxWorks) and software level (GISC-compatible communication protocols). The entire system is configured to optimize the information display and operational efficiency of a human operator controlling or supervising remote systems, control the display configuration, live video links and graphical overlays and to input information using the hard-wired switches and the touch-screen display.

IV. DEVELOPMENT APPROACH

We intend to develop the system performance specifications with the assistance of the staff at the Oak Ridge Robotics and Process Systems Division (RPSD), before we begin to design and detail the overall layout of the system. We will focus our attention on ensuring that the *RoboCon* system is able to interface to, at the beginning, to several key DoE robotics systems, such as *Rosie*, *Houdini* and the *DAWM* (Dual-Arm Work Module). However, the architecture of the system will be such that every system abiding by some very generic interface requirements should be able to be easily interfaced to *RoboCon*. The goal will be to have some fairly simple menu- and graphics-driven software modifications implemented by a trained programmer, in order to allow the interface of a new robotic system, without the need for extensive re-design, electrical routing and long-winded software developments.

V. BENEFITS & APPLICATIONS

The *RoboCon* system is a proposed solution to harness the powers of the latest in display and controls technology (hardware and software) and allow it to be configured to best suit the individual remote device, task and operator. The *RoboCon* system is intended to be an experimental platform that provides the robotics development testing agenda a reconfigurable platform to test new display configurations, operator console layouts and functionalities, computing platforms, communications protocols and other hardware control interfaces such as joysticks, track-balls, and other master input devices.

As such, its applications are fairly broad, except that we believe it to have a potentially large impact in several areas, such as:

(i) find use as an integral element of any ongoing/future Integrated Demonstrations (such as CP-5, etc.),

(ii) crucial element of telerobotic performance testing for existing robotic systems hardware (*Rosie, HOUDINI, DAWM*, etc.)

(iii) use as a tool for human factors research

ongoing at DoE laboratories, and

(iv) setting standards for interface modes and protocols for future robotic systems.

Alternate uses are currently envisioned for this system, including the ability to provide supervisory displays and possibly controls for different robot systems in different activities. The *RoboCon* control station chair, due to its modularity, can accommodate different control panels and consoles, control CPUs and even control software as long as all the interface specifications (mechanical, power, data) are adhered to. The benefit of developing the *RoboCon* system, is thus the need for only small and reduced complexity and cost consoles for current or future robot developments, since the backbone (displays, power and computing) and the development environment (software modules, computing platforms and development packages) have already been developed and can thus be provided.

VI. FUTURE ACTIVITIES

We expect to have the system specifications defined by September/October 1996 with the help of ORNL's RPSD, after which we will develop and detail a design for the DoE to review by January 1997. After acceptance, we will proceed to fabricate, assemble and test the system and demonstrate its performance on a CMU-resident *Houdini*-prototype system, before it is shipped to ORNL by July 1997. Training and assistance will be provided so that ORNL can begin their task of interfacing other robots to *RoboCon* and begin their long-term testing and evaluation phase.

VII. ACKNOWLEDGMENTS

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